

AD-A056 710 NEW MEXICO STATE UNIV LAS CRUCES PHYSICAL SCIENCE LAB F/G 9/5  
RESEARCH AND DEVELOPMENT OF ANTENNAS FOR ROCKETS AND SATELLITES--ETC(U)  
MAR 78 A WATERMAN, D G HENRY F19628-75-C-0072

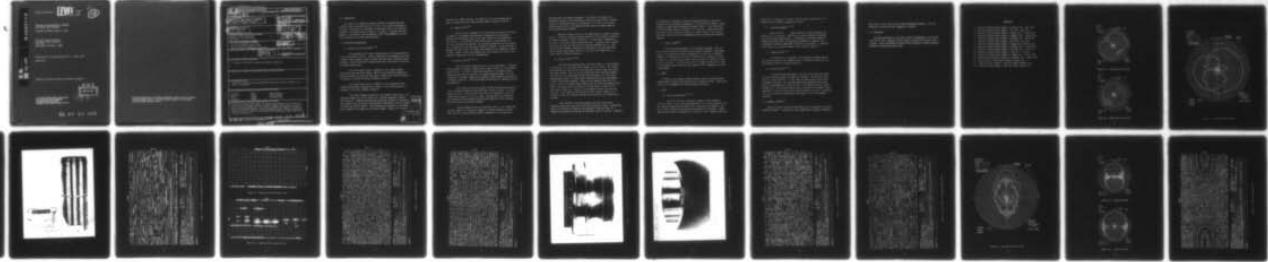
UNCLASSIFIED

PR-00897

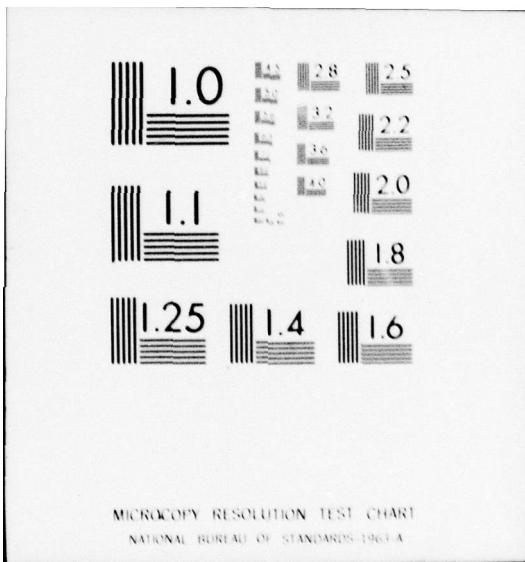
AFGL-TR-78-0095

NL

1 OF 1  
AD  
A056 710



END  
DATE  
FILED  
9-78  
DDC



AD No. \_\_\_\_\_  
DDC FILE COPY

AD A 056710

AFGL-TR-78-0095

LEVEL II

(10)

RESEARCH AND DEVELOPMENT OF ANTENNAS  
FOR ROCKETS AND SATELLITES

Alexander Waterman, Dennis G. Henry

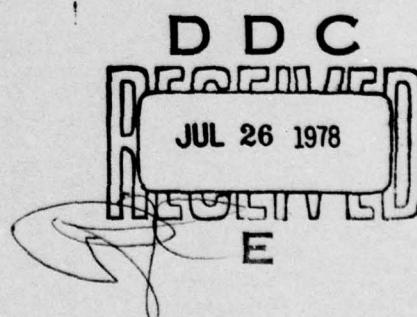
Physical Science Laboratory  
New Mexico State University  
Box 3-PSL  
Las Cruces, New Mexico 88003

Final Report For Period February 1975 - January 1978

March 1978

Approved for Public Release; distribution unlimited.

AIR FORCE GEOPHYSICS LABORATORY  
AIR FORCE SYSTEMS COMMAND  
UNITED STATES AIR FORCE  
HANSOM AFB, MASSACHUSETTS 01731



78 07 24 019

**Qualified requestors may obtain additional copies from the Defense Documentation Center. All others should apply to the National Technical Information Service.**

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

<b>REPORT DOCUMENTATION PAGE</b>		<b>READ INSTRUCTIONS BEFORE COMPLETING FORM</b>
1. REPORT NUMBER <b>AFGL-TR-78-095</b>	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) <b>RESEARCH AND DEVELOPMENT OF ANTENNAS FOR ROCKETS AND SATELLITES</b>		5. TYPE OF REPORT & PERIOD COVERED <b>Final Report, February 1975-January 1978</b>
6. AUTHOR(s) <b>Alexander Waterman Dennis G. Henry</b>		7. PERFORMING ORG. REPORT NUMBER <b>PR-00897</b>
8. PERFORMING ORGANIZATION NAME AND ADDRESS <b>Physical Science Laboratory New Mexico State University Box 3-PSL Las Cruces, New Mexico 88003</b>		9. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS <b>62101F 7659-01-01 687659</b>
10. CONTROLLING OFFICE NAME AND ADDRESS <b>Air Force Geophysics Laboratory Hanscom AFB, Massachusetts 01731 Contract Monitor: Raymond E. Wilton/LCS</b>		11. REPORT DATE <b>March 1978</b>
12. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) <b>(12) 28 p.</b>		13. NUMBER OF PAGES <b>26</b>
14. SECURITY CLASS. (of this report) <b>Unclassified</b>		
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report) <b>A - Approved for public release; distribution unlimited.</b>		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES <b>Previously produced related publications under this contract appear in the Table of References.</b>		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <b>Stripline Antenna Array Telemetry      Beacon                   S-band                   C-band                   X-band      Sphere Antennas                   Aries Antennas                   Corporate Feed</b>		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <b>The Physical Science Laboratory, New Mexico State University has conducted research and development studies of antenna designs under contract to the Air Force Geophysics Laboratory. The studies included development of telemetry, beacon and command antennas in various frequency bands. Different mechanical configurations for rockets and satellites were investigated under direction of the contract monitor.</b>		

## 1.0 INTRODUCTION

This report is a summary of various scientific investigations and technical projects pursued from 1975 to 1978. More detailed information on each of the subjects is available by obtaining a copy of the indicated reference. The authors wish to thank J. E. Litton, R. Lanphere and other members of the Physical Science Laboratory (PSL) electromagnetics section who contributed to the work reported herein.

## 2.0 STRIPLINE CONFIGURATIONS

### 2.1 Models 55.507 and 55.508<sup>1-3, 14</sup>

PSL developed both of these antenna arrays to be flush mounted on a nine inch diameter vehicle. They are physically interchangeable and share a common S-band telemetry design, however they each have a different beacon frequency. Model 55.507 has a C-band beacon array, while model 55.508 uses an S-band beacon design.

The C-band beacon array is composed of four linear elements mounted 90° apart and fed in phase. There are two radiating elements for each polarization, and they are 180° apart. Typical roll plane patterns at a frequency of 5.8 GHz are shown in Figures 1a and 1b.

The S-band beacon array is composed of two orthogonal linear elements mounted 180° apart and fed in phase. A roll plane pattern at a frequency of 2.89 GHz is shown in Figure 2.

The S-band telemetry antenna is a ten element linear array. The radiating elements are fed in phase with a constant impedance corporate feed structure. Impedance matching and equal power division is achieved by this symmetrically fed network using parallel combinations and line lengths to obtain the desired results. This decreases the necessity for extremely close tolerance line widths in the circuit design. Figure 3 is a view of

White Section		<input type="checkbox"/>
Buff Section		<input type="checkbox"/>
.....		
.....		
DISTRIBUTION/AVAILABILITY CODES		
Dist.	AVAIL. and/or SPECIAL	
A		

this unit on a flight payload. The effects of the spike antennas may be seen by comparing the roll plane patterns shown in Figures 4a and 4b.

#### 2.2 Model 55.455<sup>4-10</sup>

This array was developed for the Arcas vehicle which is 4.5 inches in diameter. Aerodynamic and mechanical considerations precluded any antenna structure being either on the outer surface or flush mounted on this vehicle. An additional payload section with a flush mounted unit was also considered unacceptable. The resulting design was an array mounted on a cylinder which was then placed inside the vehicle. It was necessary to machine the vehicle skin to provide five windows for the elements to radiate through. Figure 5 shows the completed unit, and Figure 6 is a copy of the radiation contour plot for this configuration.

#### 2.3 Model 55.511<sup>4-8, 11, 15</sup>

This system was designed for use in a ten inch sphere. Originally PSL developed a 12 element S-band TM array (model 55.509) for this diameter sphere in 1972. In 1976 a C-band array was added to the sphere without increasing the area set aside for the original antenna design. Our first attempt was to slightly compress the original S-band design and maintain the 12 element capability. This became model 55.510S and its' radiation pattern was unaltered.

The C-band beacon portion (model 55.510C) was developed using two linear orthogonal elements placed 180° apart and fed in phase. The final design was only 2.7 cm wide but it still had to be mounted on top of the S-band array because of a lack of space. Although both units exhibited good radiation characteristics the mounting configuration and subsequent potting techniques were barely adequate.

Further redesign led to an S-band TM tradeoff. The S-band array was made smaller by reducing the number of radiating elements to eight. This resulted in some radiation pattern degradation but the mechanical

advantage made the tradeoff acceptable. For comparison purposes, two simplified versions of the TM radiation contour plots are shown in Figures 7a and 7b. Both patterns are at a frequency of 2.25 GHz, and the cross hatched areas are 10 to 14 dB below isotropic while the shaded areas are 14 dB or more below isotropic.

Radiation contour plots for the C-band beacon are shown in Figures 8 and 9. The entire system now known as model 55.511 is shown in Figure 10. The flight condition is shown in Figure 11. In the launch configuration, the sphere is installed within a metal nose cone. To ensure correct systems operation, the nose cone has had four apertures machined into it. This allows both the telemetry and beacon to be tested in the pre-launch mode, and the TM and radar ground stations to lock on to the signal prior to sphere ejection during the mission.

#### 2.4 Model 55.385<sup>3-6, 9-12</sup>

This array was fabricated for the Aries vehicle. It was designed to be mounted on a ring whose outer diameter is 37.25 inches. The antenna was fabricated in six pieces and then harnessed together using coax cables and power dividers. Each of the six modules had eight radiating elements. The array was 2.75 inches wide and was installed under a 0.25 inch thick aluminum heat shield. The heat shield installation requires approximately 20 feet of EMI gasket material. There are two complete arrays for each vehicle, one for the Sensor Module (SM) and one for the Target Engine Module (TEM). Full scale radiation contour plots were taken on a mock up with and without a nose cone. Figure 12 is a radiation contour plot with the nose cone. This simulates the SM with the doors closed. Figure 13 is a radiation contour plot without the nose cone, and this is the condition for the TEM.

After arrival of the sensor module, the roll plane pattern comparison tests were done with the SM doors opened and closed. Although the effect of the doors is visible on the patterns, it was felt that the degradation was minimal and would not adversely effect the system. Originally

the system was to operate for three TM links and therefore, tests were conducted at three different frequencies. A fourth link was added by using a single 8 element module designated as model 55.385T. It was fabricated with tapered edges, and was screwed to the outer skin. There was no heat shield and the TM coverage was limited to a small portion of the vehicle. Since this link was only for housekeeping data the coverage was considered adequate.

#### 2.5 Model 55.380<sup>10-12</sup>

This array was developed for two different programs. Both the Spice vehicle and the Irbis vehicle are 38 inches in diameter. The antenna array is flush mounted and uses six modules for a total of 48 radiating elements. A gain pattern of the first flight array on a mock up is shown in Figure 14. During the next report period, we plan to complete the tests for these programs. A radiation data set on a flight payload will be taken at the antenna range, and we will test some of the RF components in the PSL vacuum chamber.

#### 3.0 BAMM<sup>8</sup>

A system of five separate S-band telemetry stubs and three different command antenna systems were developed for a parachute payload. These units were used on the BAMM project and functioned as expected.

#### 4.0 ARIES

##### 4.1 C-band Investigation<sup>4, 6, 13</sup>

Extensive tests were conducted on several C-band components supplied to PSL. All of the testing was done on a 37.25 inch diameter mock up. Data was taken using an array of two, three and four elements. The best overall coverage was obtained from an array of two elements. Sample patterns were taken at frequencies of 5.8 and 5.72 GHz. Complete data sets

were run at a frequency of 5.76 GHz. The roll plane patterns for a two element array are shown in Figures 15a and 15b.

#### 4.2 X-band Development<sup>5, 9, 11</sup>

Model 39.003, a ~~one~~-ended, dielectric filled waveguide, was developed for this project. There were two units installed on opposite side of the target engine module. A coax switch in the TEM operated by command would then select the appropriate antenna for tracking. This arrangement provided an additional 3 dB gain for the system. A radiation contour plot for an axially mounted slot is shown in Figure 16.

#### 4.3 Command System<sup>9, 11</sup>

A standard pair of PSL model 4.003 quadraloop antennas mounted 180° apart was used for the command system. A radiation contour plot for this diameter vehicle is shown in Figure 17.

#### 4.4 X-band Tracker<sup>10, 11</sup>

A tracking system developed by the Cubic Corporation was tested at the PSL antenna range on two separate occasions. The unit was tested the first time in May 1977. At that time the sensor module had no other instruments installed. PSL provided operational personnel and recorded data for representatives of AFGL and Cubic. The second test was in early November 1977. PSL provided support only and no data was recorded. Representatives of AFGL and Cubic were on hand to observe the tests. The vehicle was in its pre-launch configuration with almost all of its instruments installed.

#### 5.0 ANTENNAS SHIPPED<sup>1-12</sup>

During the report period PSL fabricated, tested and shipped 57 pairs of standard antennas. In addition to these quadraloops, spikes and valentines,

there were 12 other units such as stubs and waveguide antennas. PSL also developed 39 stripline arrays composed of 73 pieces.

#### 6.0 CONCLUSION

The topics discussed in this report cover the highlights of the efforts from 1975 to 1978. Ongoing projects include the Aries and the Spice, Irbs programs. Future developments include studies relating to antenna bandwidth, radiation coverage and physical size.

#### REFERENCES

1. Quarterly Progress Report Number 1, February 1975 - April 1975.
2. Quarterly Progress Report Number 2, May 1975 - July 1975.
3. Quarterly Progress Report Number 3, August 1975 - October 1975.
4. Quarterly Progress Report Number 4, November 1975 - January 1976.
5. Quarterly Progress Report Number 5, February 1976 - April 1976.
6. Quarterly Progress Report Number 6, May 1976 - July 1976.
7. Quarterly Progress Report Number 7, August 1976 - October 1976.
8. Quarterly Progress Report Number 8, November 1976 - January 1977.
9. Quarterly Progress Report Number 9, February 1977 - April 1977.
10. Quarterly Progress Report Number 10, May 1977 - July 1977.
11. Quarterly Progress Report Number 11, August 1977 - October 1977.
12. Quarterly Progress Report Number 12, November 1977 - January 1978.
13. Letter Report, C-band Beacon Antennas, January 1976.
14. Scientific Report Number 1, AFGL-TR-76-0066, February 1976.
15. Scientific Report Number 2, AFGL-TR-77-0064, February 1977.

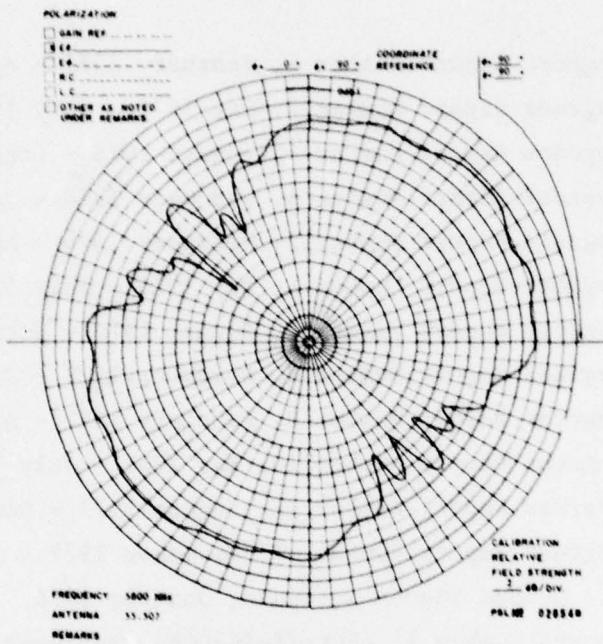


Figure 1a. C-band Beacon Roll Plane

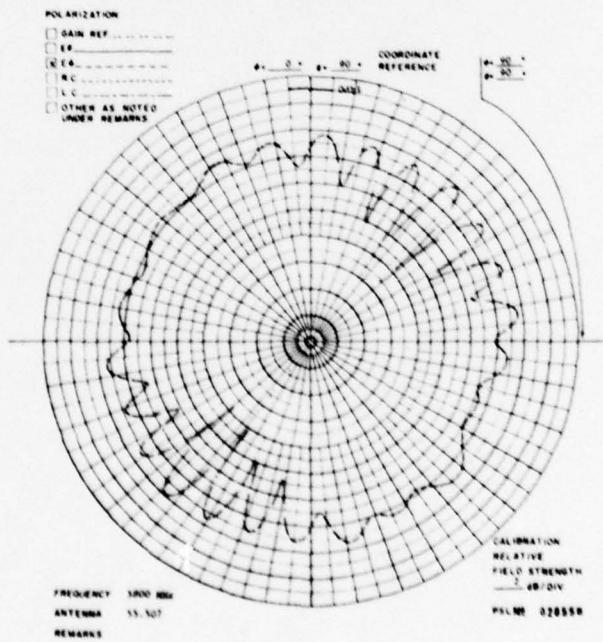


Figure 1b. C-band Beacon Roll Plane

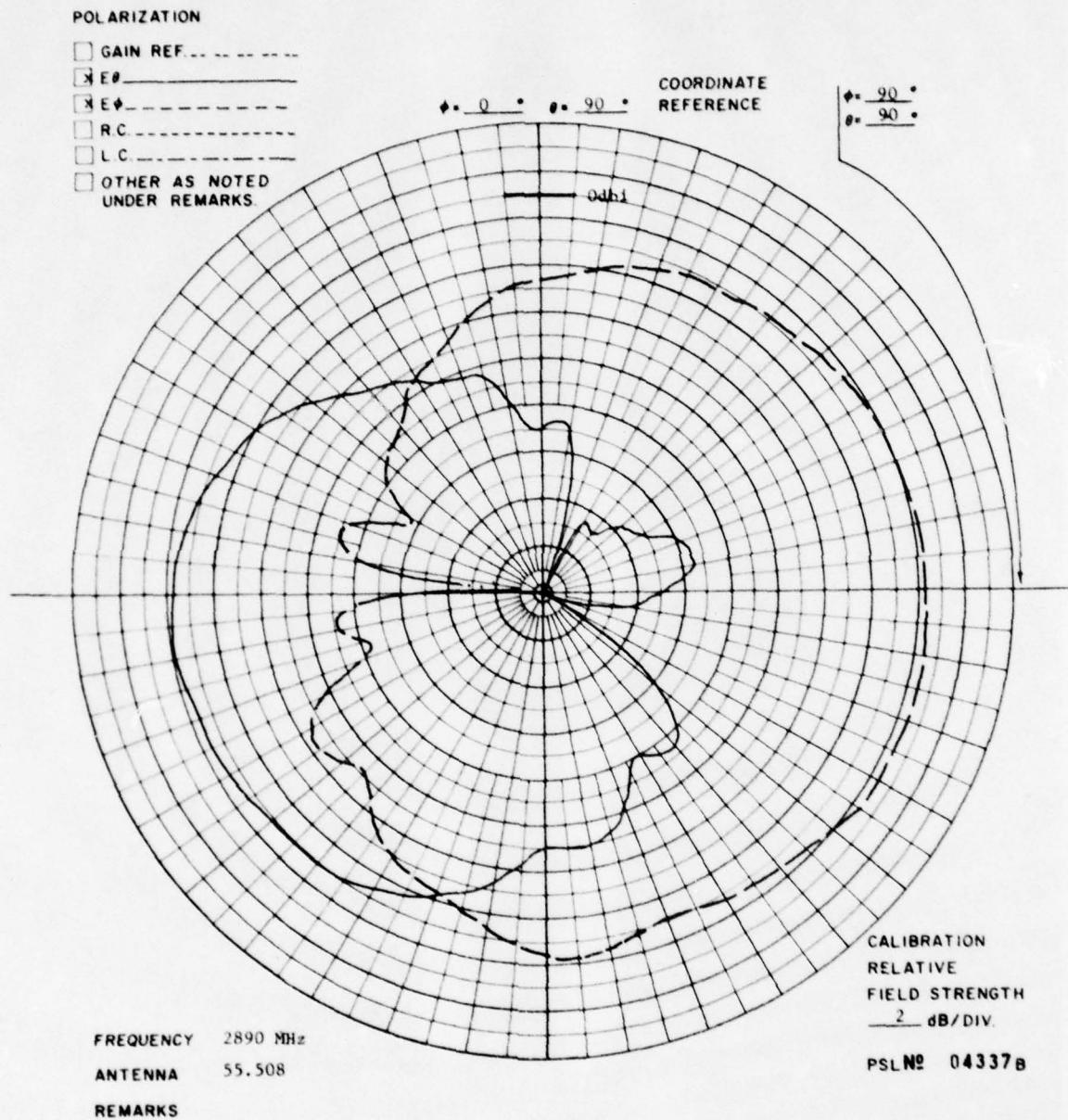


Figure 2. S-band Beacon Roll Plane

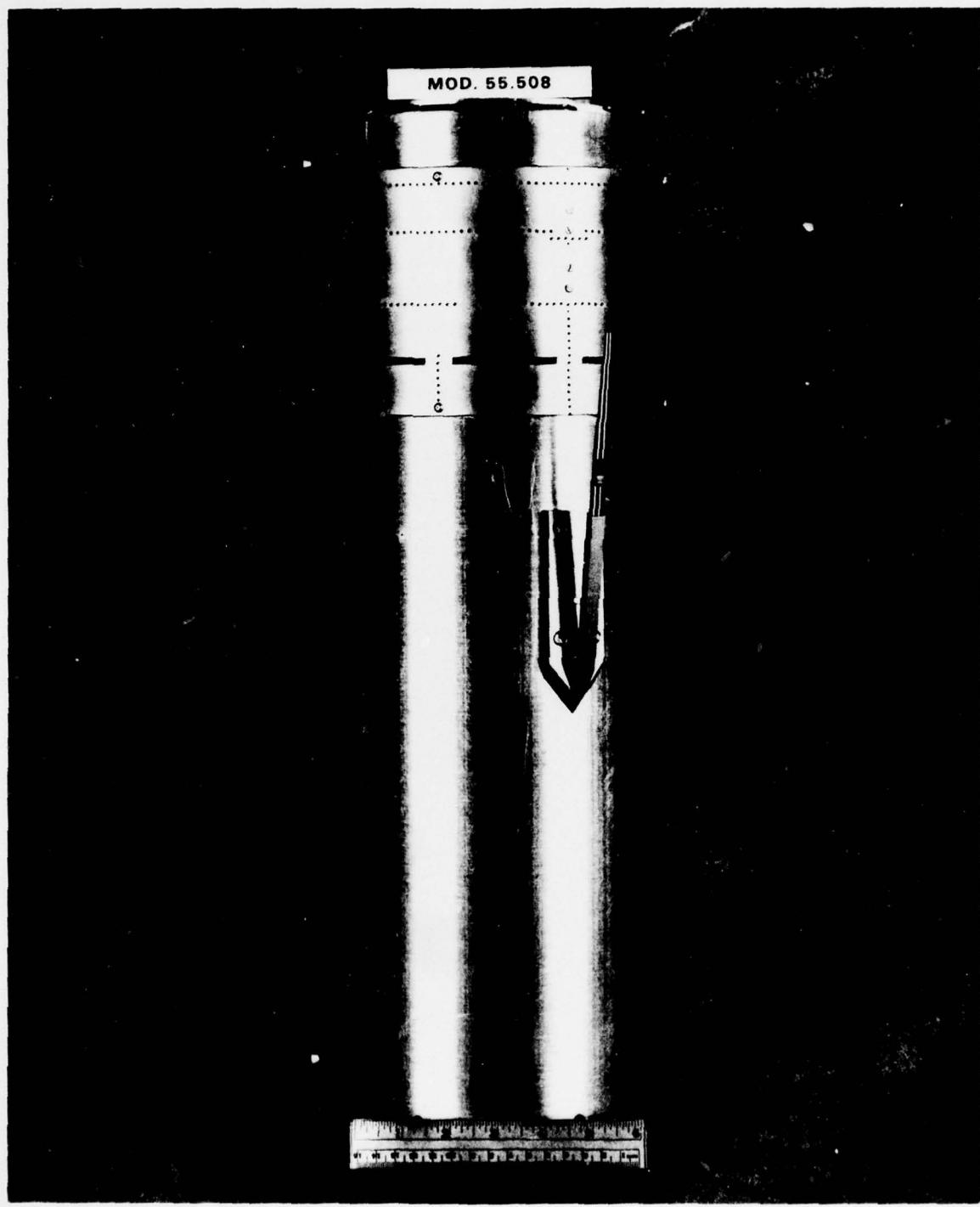


Figure 3. Flight Payload Model 55.508

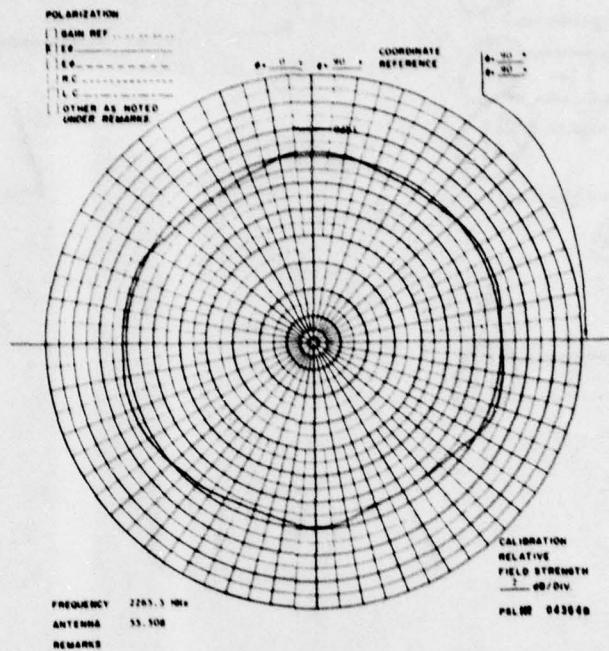


Figure 4a. S-band TM Roll Plane

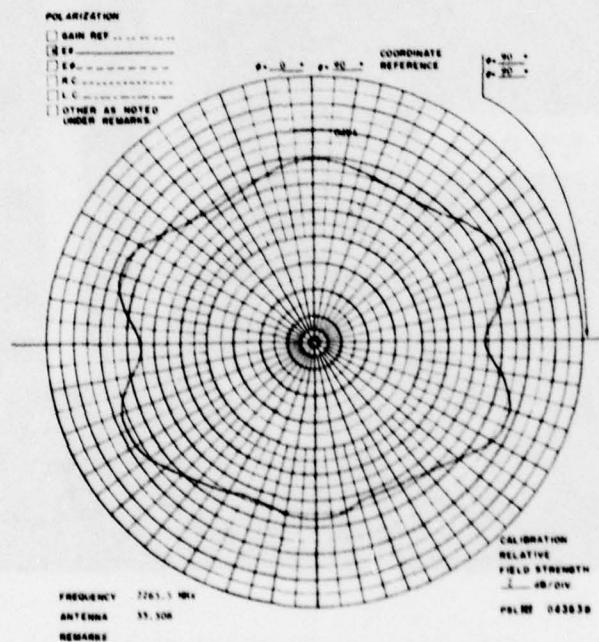


Figure 4b. S-band TM Roll Plane

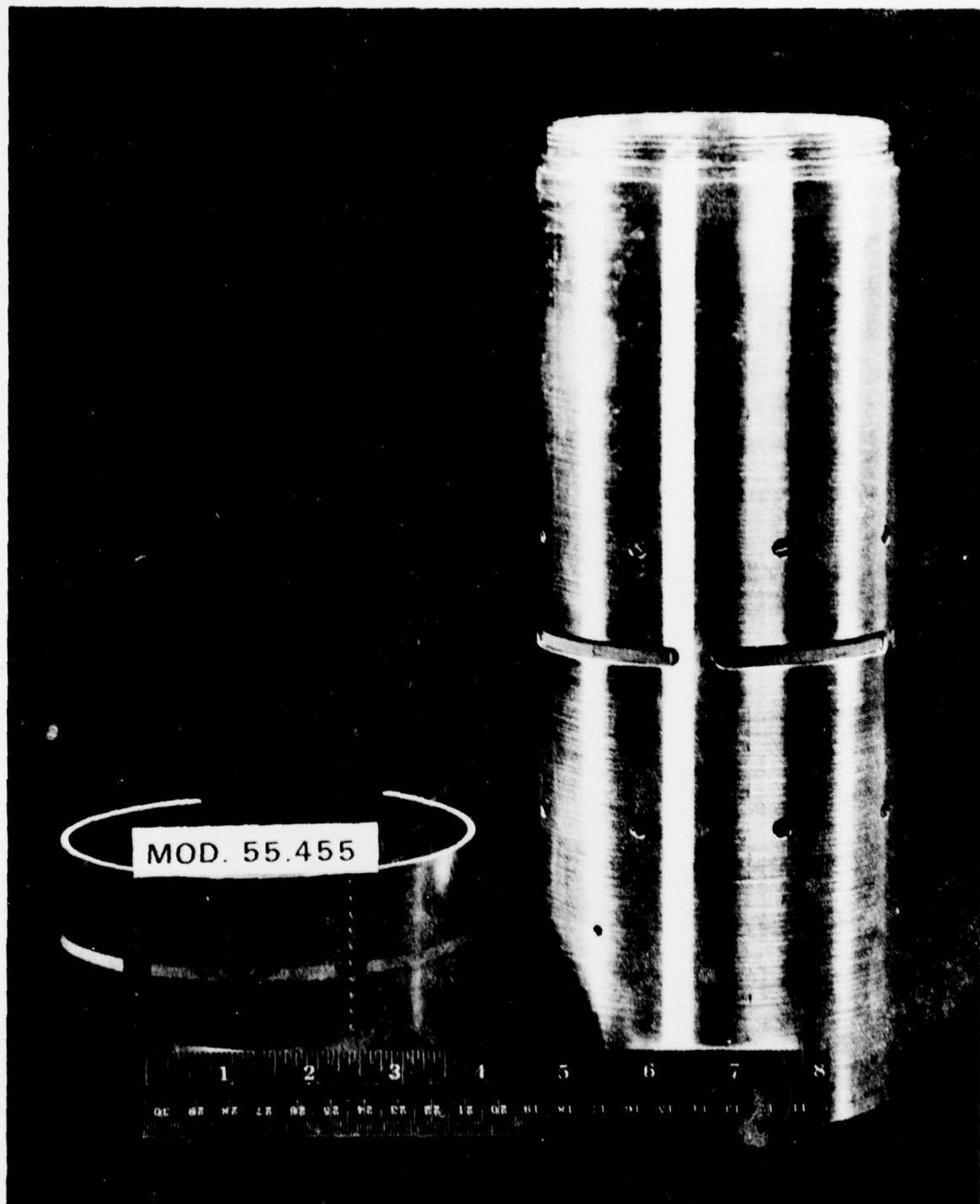


Figure 5. Areas Model 55.455

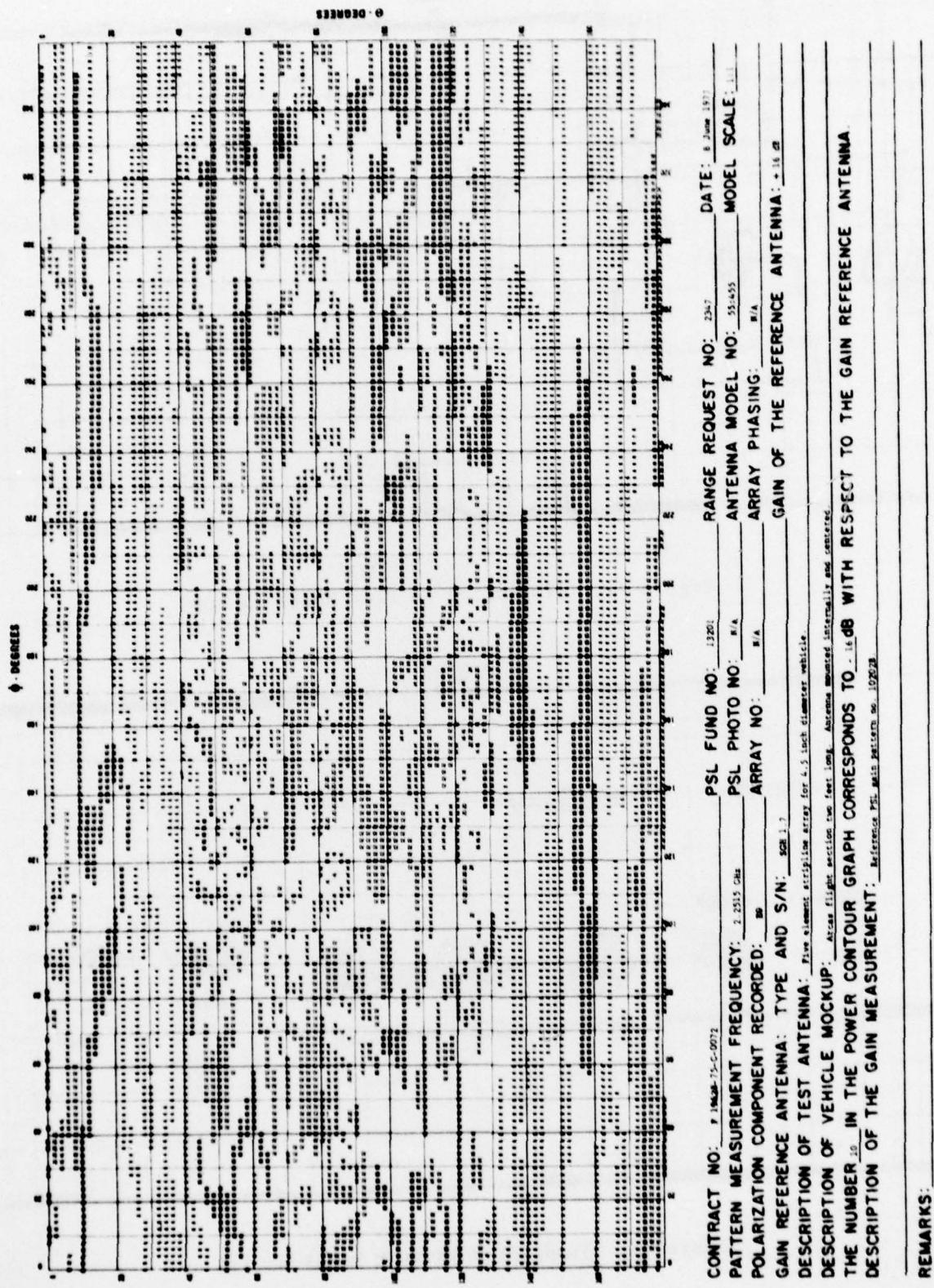


Figure 6. Arcas Model 55.455 Radiation Contour Plot

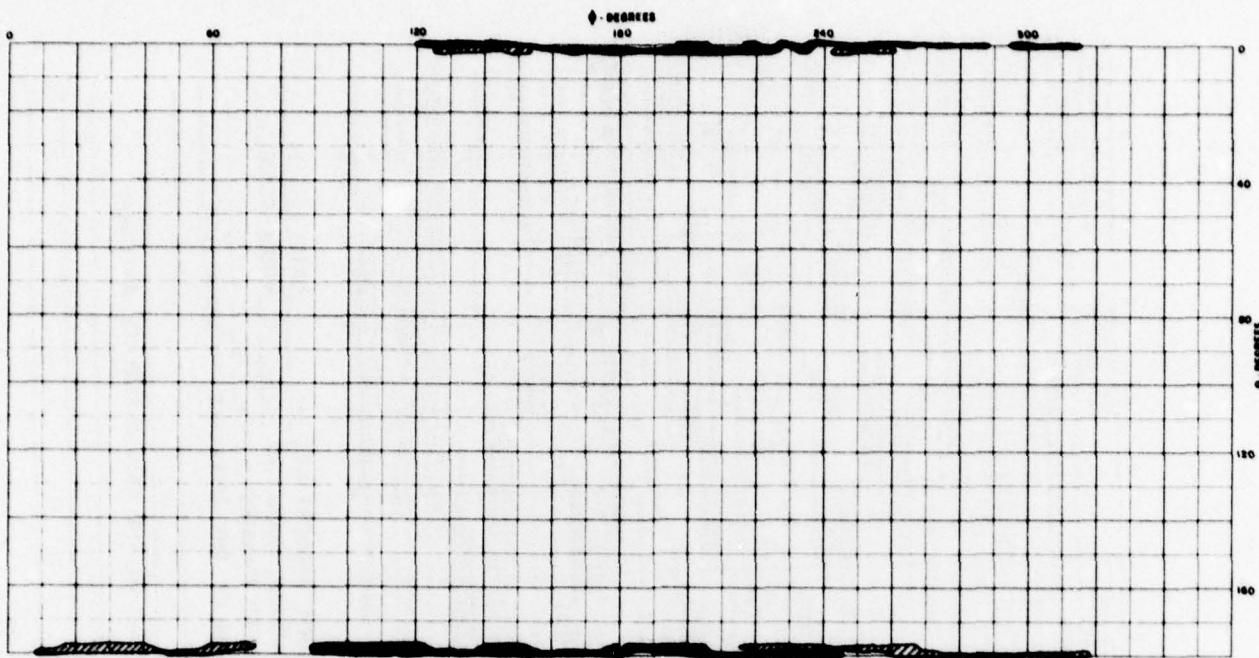


Figure 7a. Simplified TM Plot Model 55.509

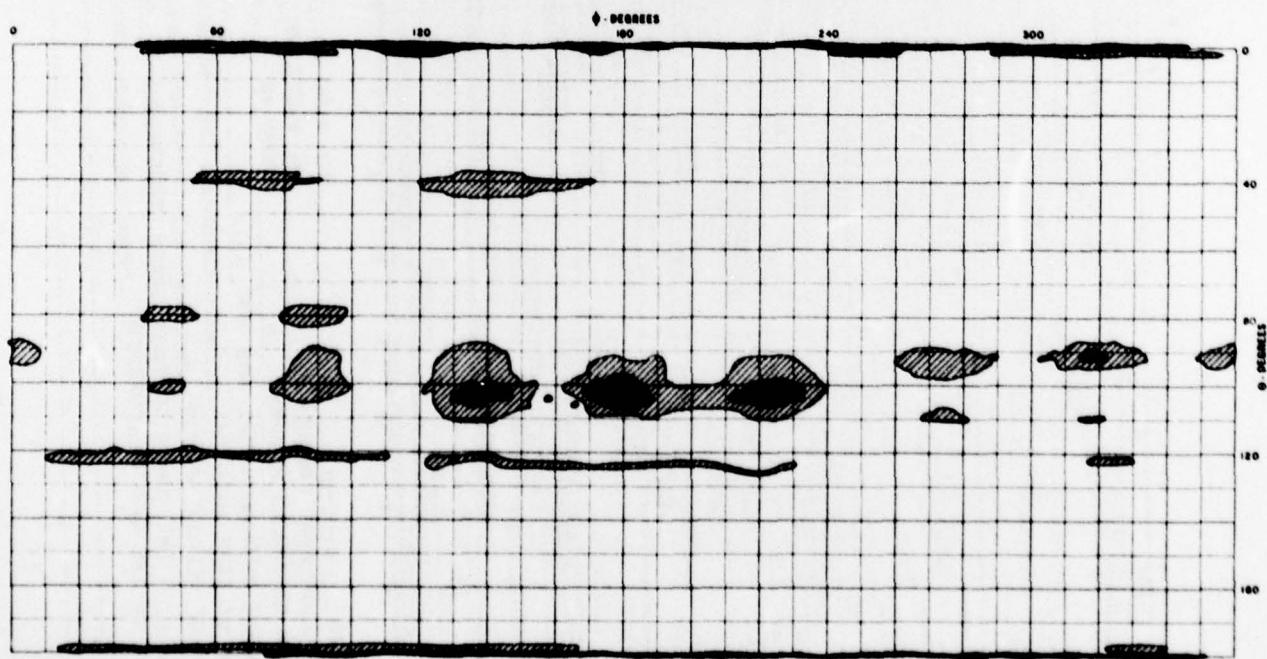


Figure 7b. Simplified TM Plot Model 55.511

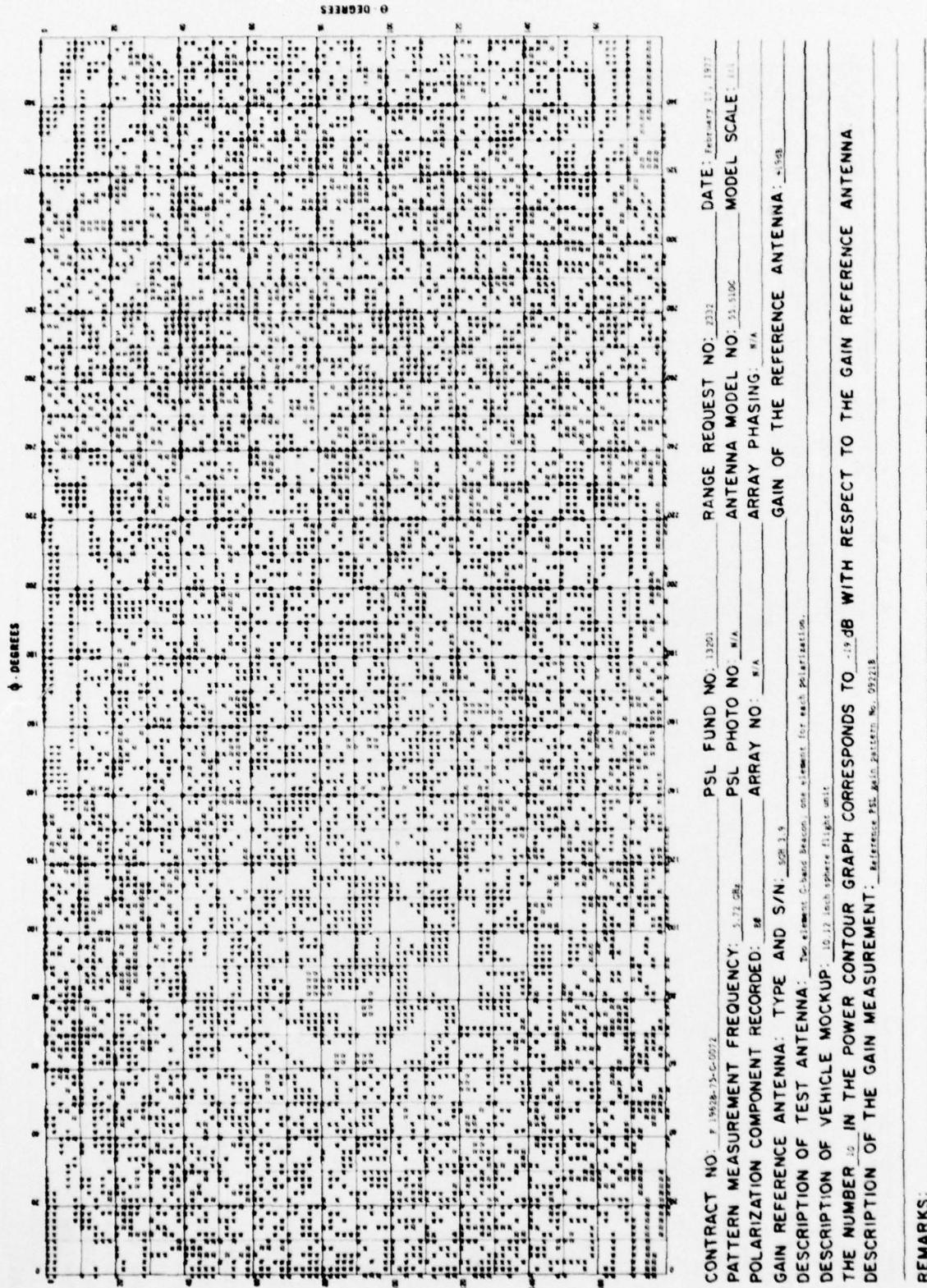


Figure 8. C-band Model 55.510C E6

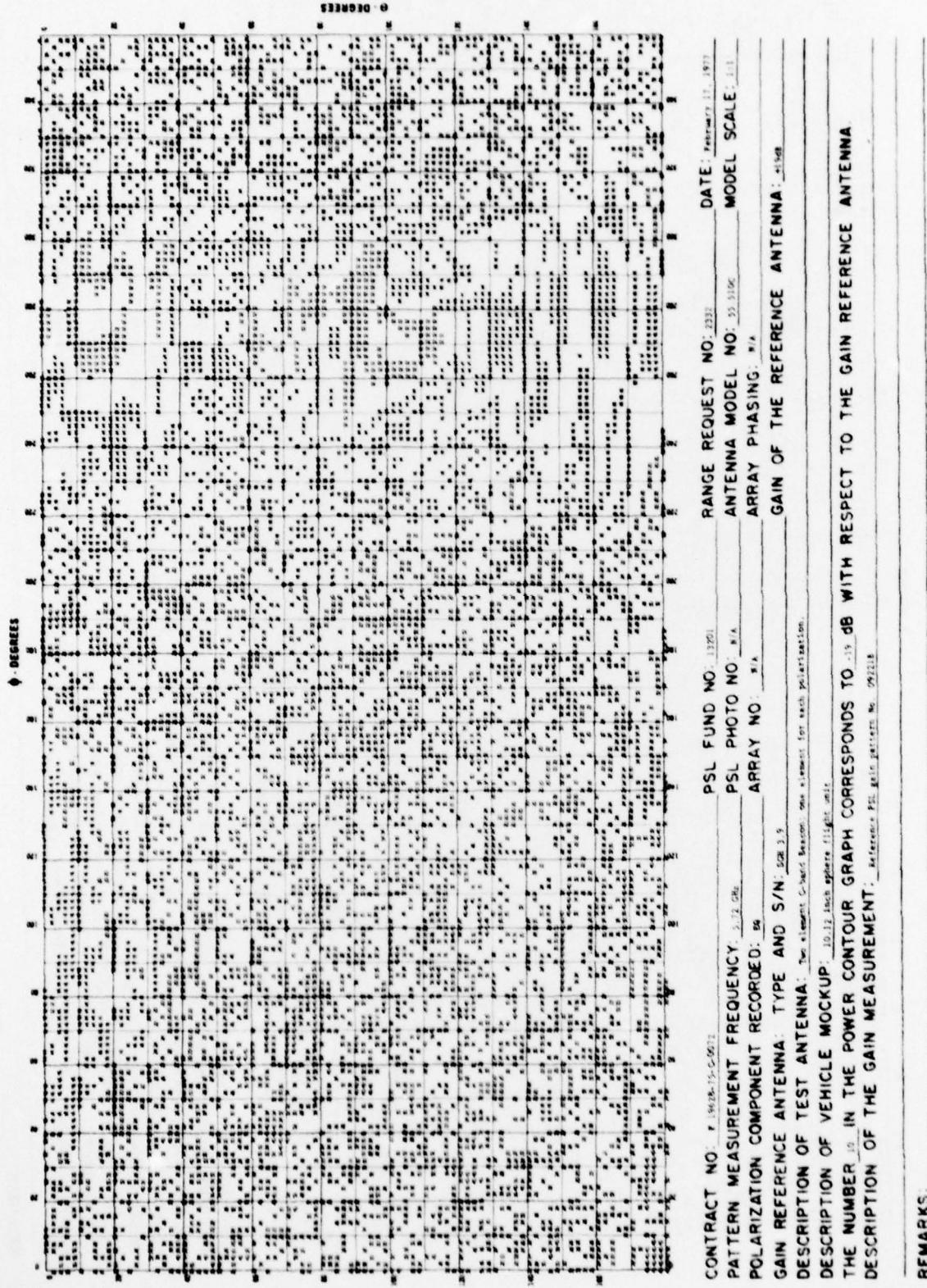


Figure 9. C-band Model 55.510C E $\phi$

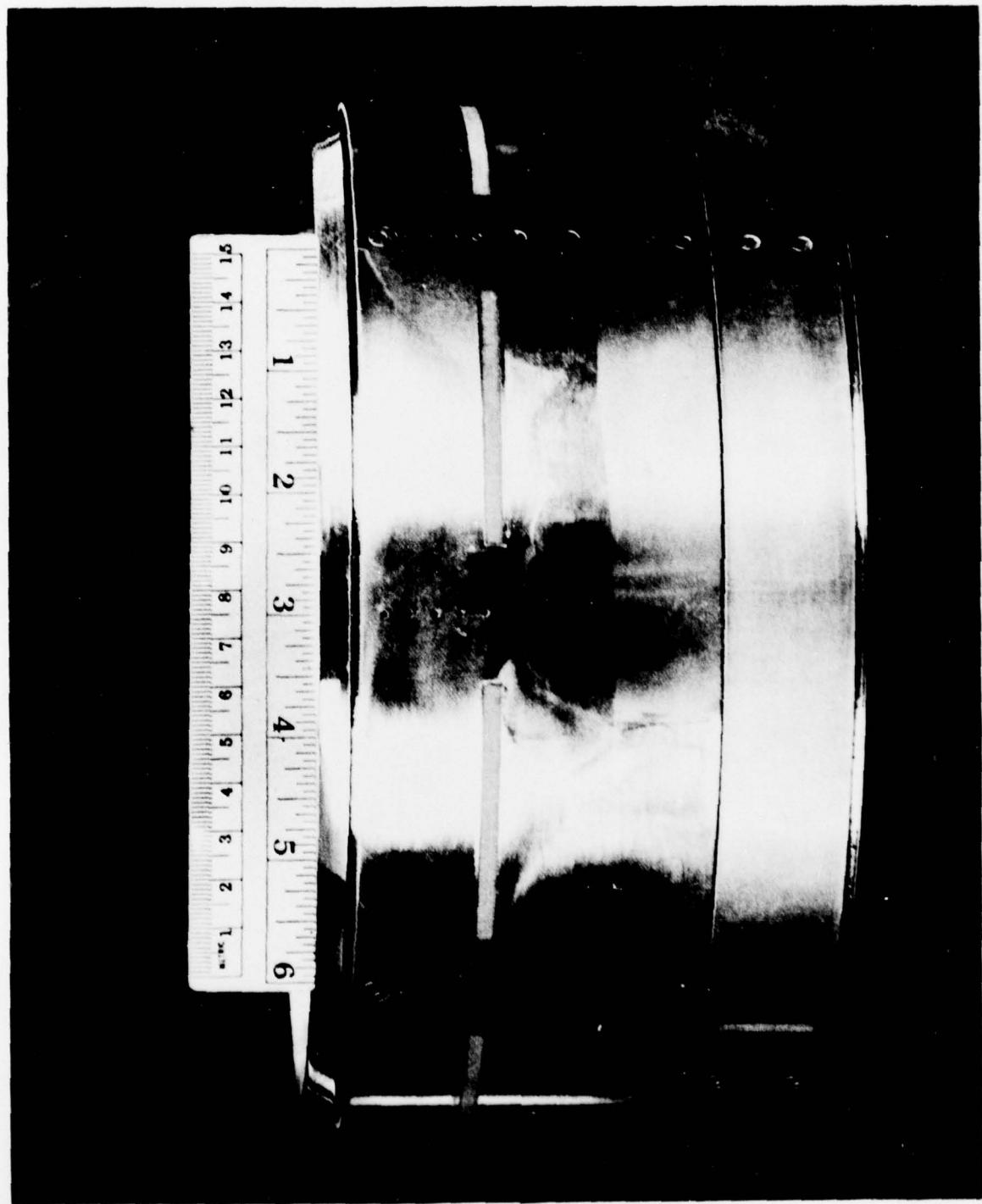


Figure 10. S-band and C-band 10 inch Sphere Model 55.511

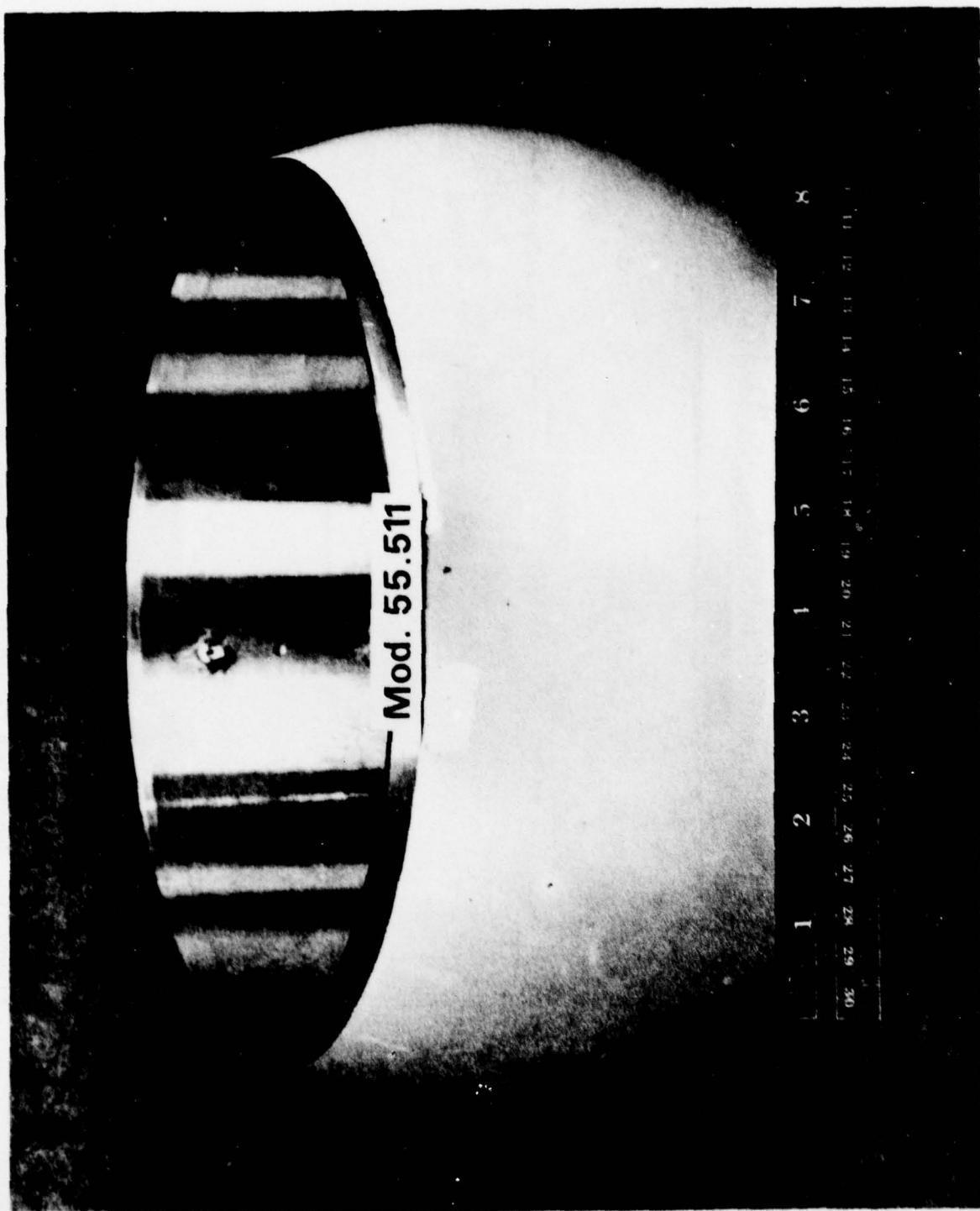


Figure 11. Flight Unit Model 55.511

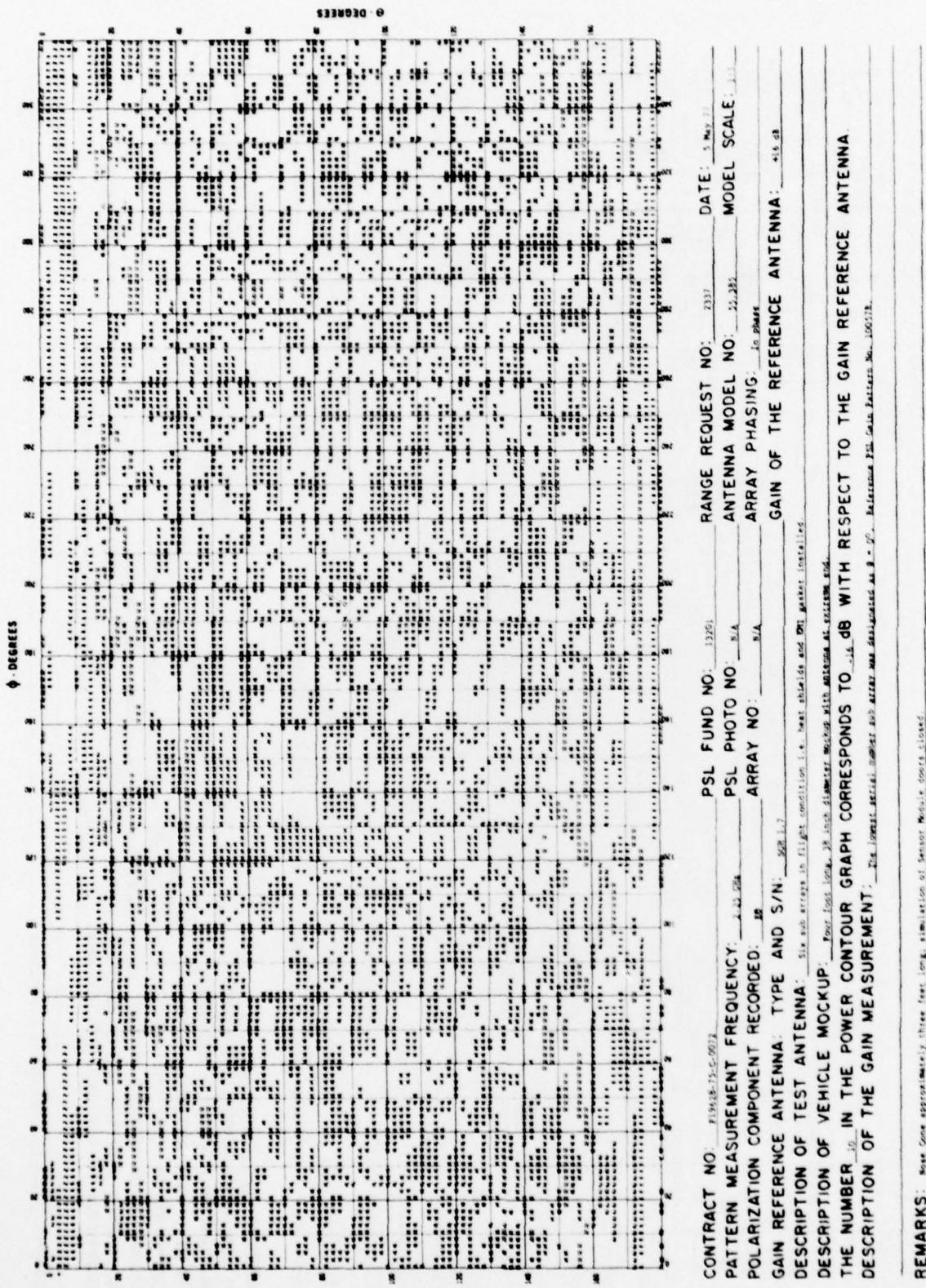


Figure 12. Aries Model 55.385 Sensor Module

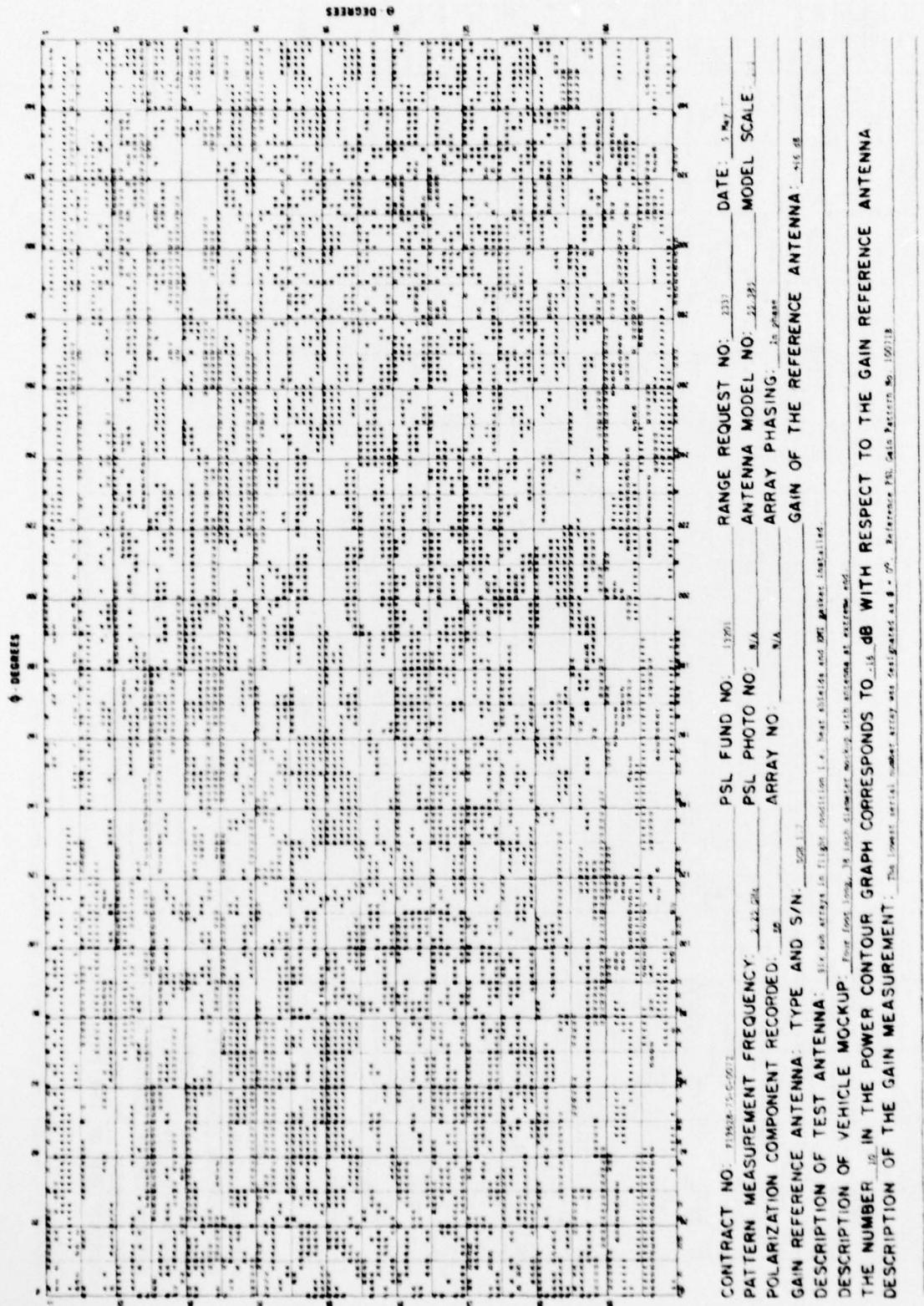


Figure 13. Aries Model 55.385 Target Engine Module

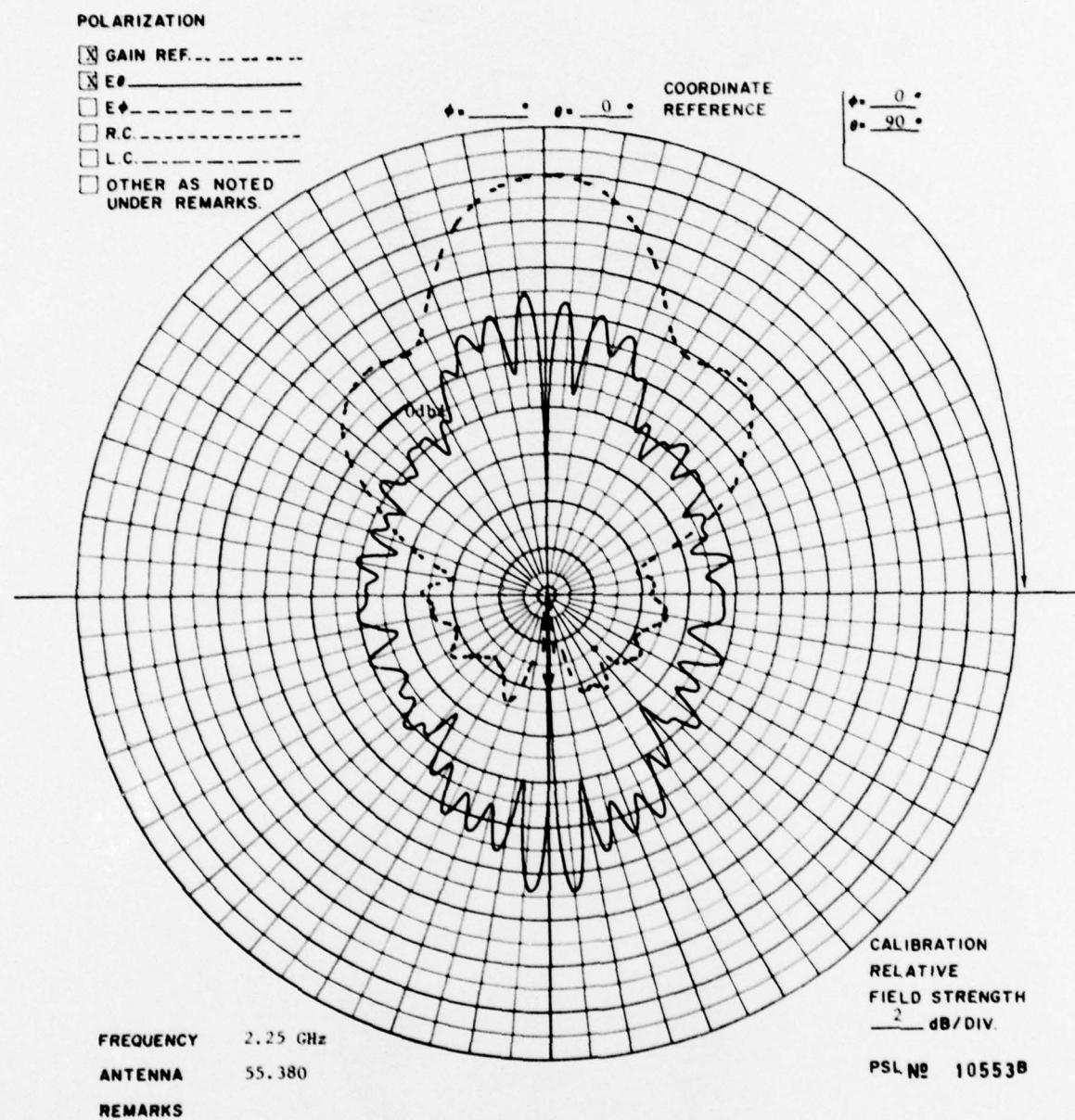


Figure 14. Gain Reference Mod 55.380

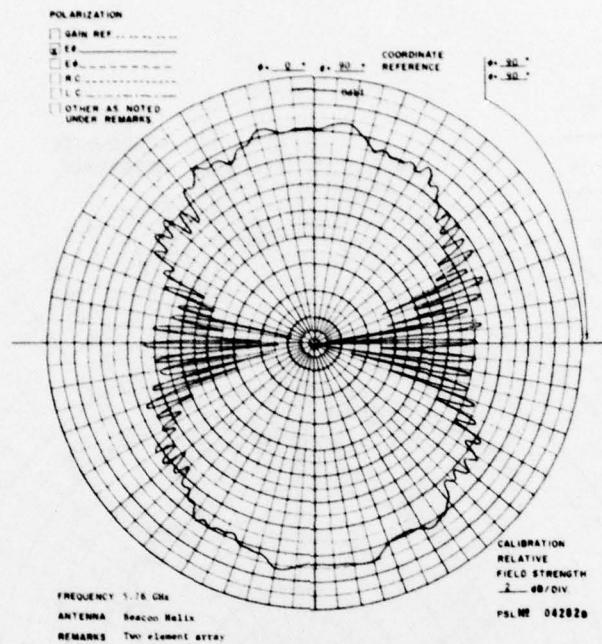


Figure 15a. C-band Roll Plane

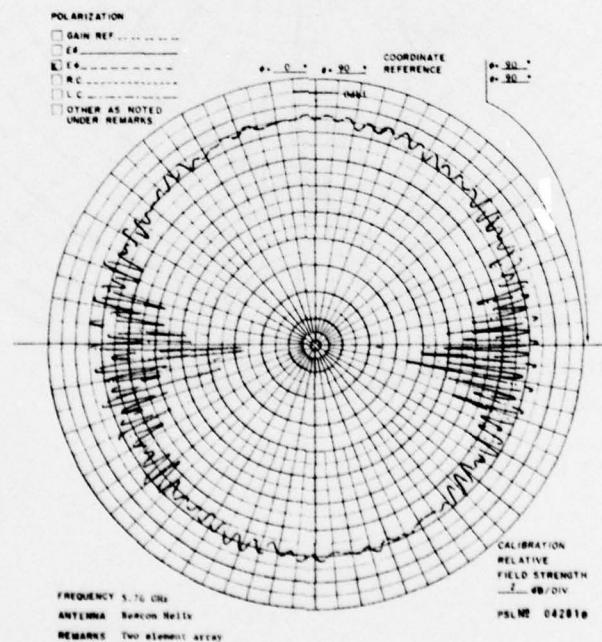


Figure 15b. C-band Roll Plane

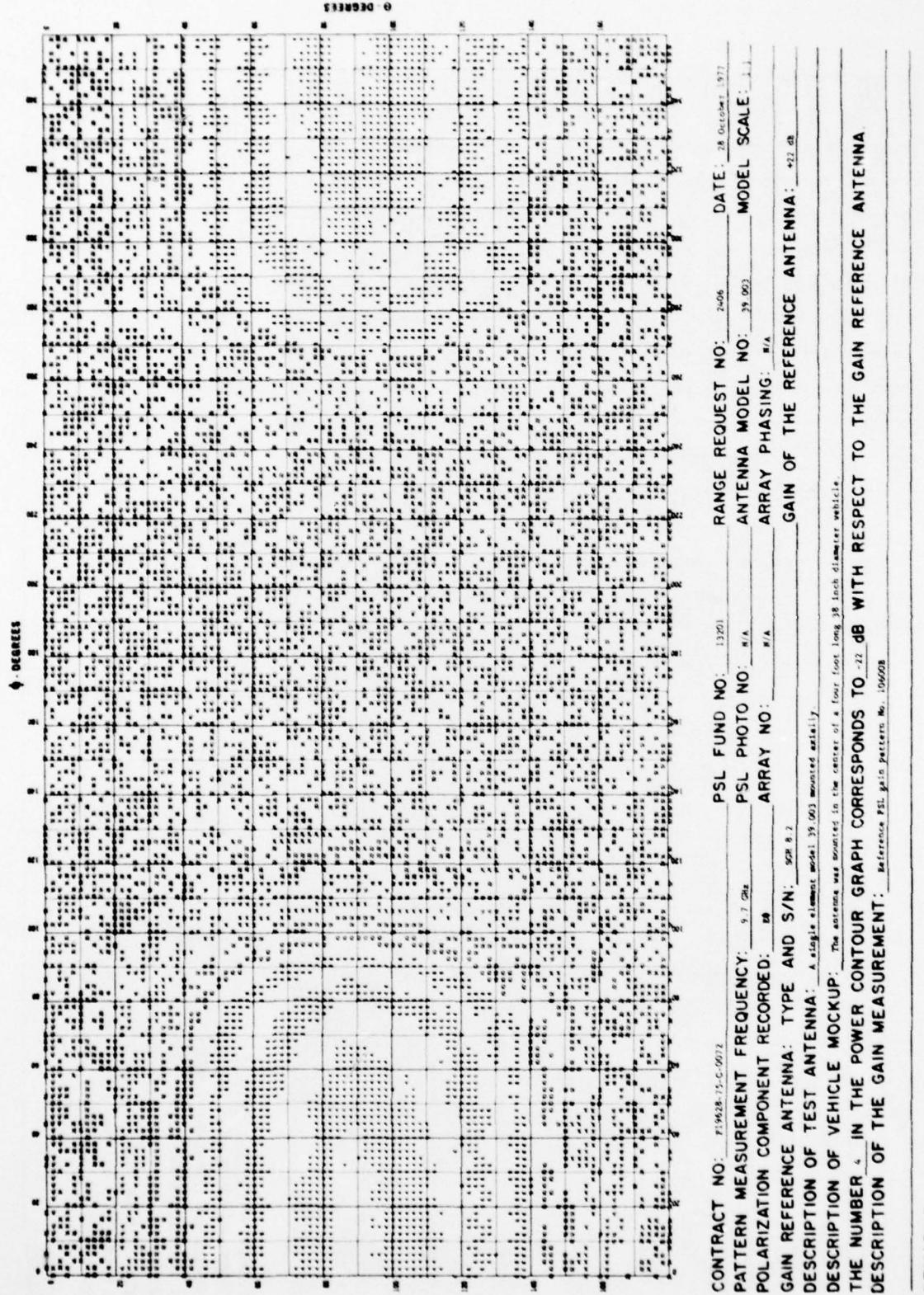


Figure 16. Axial Slot Model 39.003

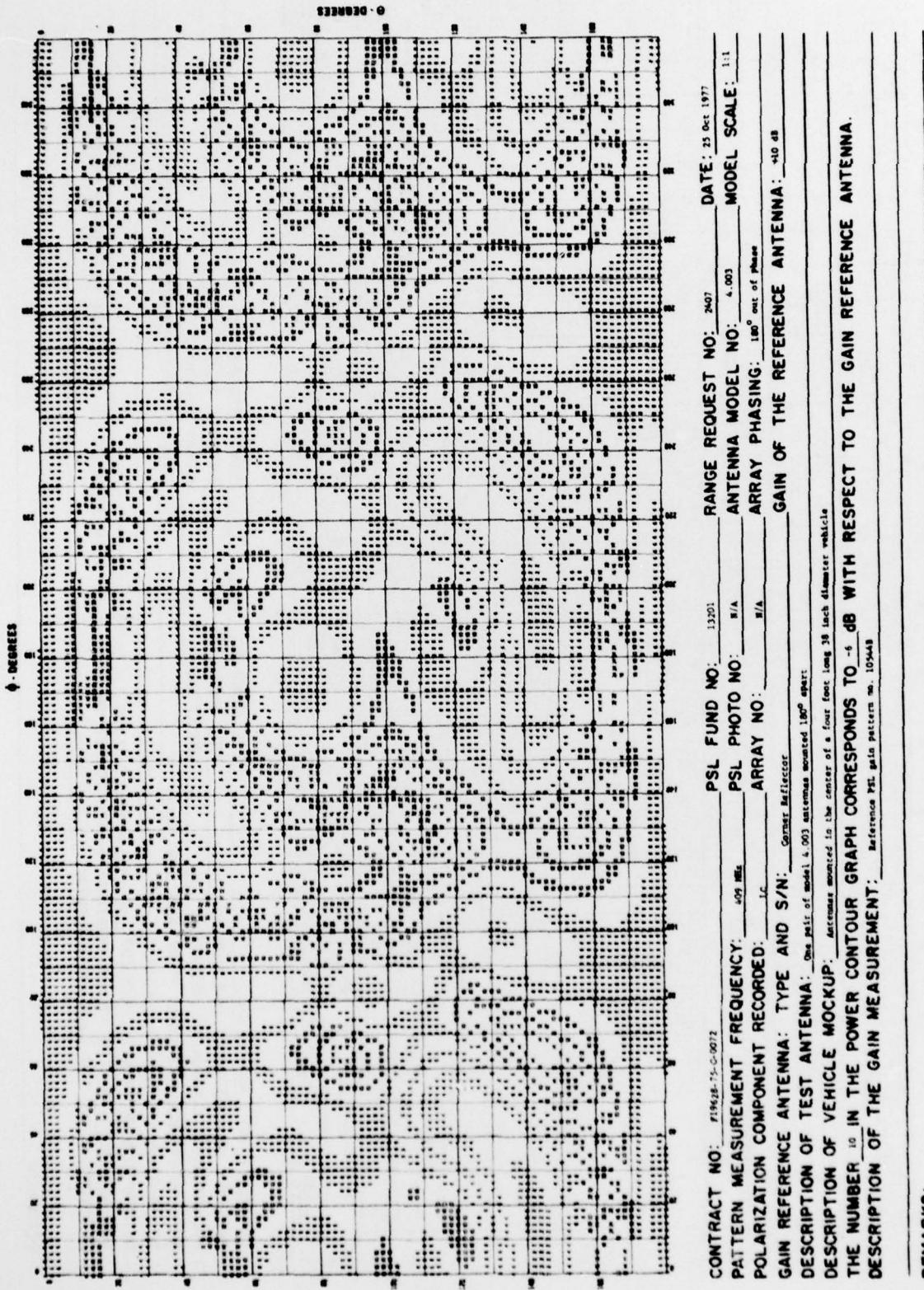


Figure 17. Command Model 4.003